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EXPLORATION FOR MINERAL DEPOSITS IN THE UAR

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EXPLORATION FOR MINERAL DEPOSITS IN THE UAR

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Application of Modern Criteria of Geological Exploration

1. Geological methods have been the earliest and most commonly utilised so far in mineral exploration in the UAR. Prototypes to some present-day geological methods have been used in Ancient Egypt, however, the Nineteenth Century marks the application of scientific geological exploration and mapping. At present modern criteria of geological exploration are taken into consideration, they imply using different geological guides including regional, mineralogical, structural, lithological, stratigraphic and physiographic. Regional guides are particularly suited for selecting large regions favourable for mineral deposition; while the others are used mainly for detailed exploration within these favourable regions.

2. Metallogenetic provinces and epochs: Regional guides may be expressed in terms of metallogenetic provinces and epochs where the geological development of a region creates conditions favourable for mineral deposition in space and time. These are useful for the general appreciation of the potentialities of the mineral wealth in individual countries. Growth of geological knowledge, recognition of mineral types and absolute age determinations have led to the gradual establishment of some metallogenetic epochs and provinces in the UAR and to observe their relation to comparable ones in Africa, western Asia and southern Europe, such interrelations are briefly summarised as follows:

(a) Metamorphosed iron ores of the Lake Superior type are the oldest known deposits in the UAR. They occur in metasediments believed to be corresponding to the Karagwe-Ankolean cycle estimated by Holmes and Cahen (1) to be 1200 - 1400 million years in age. Similar deposits occur in the Sudan, Saudi Arabia, and Central and West Africa.

(b) Chromite, ilmenite, etc. occur in ultrabasic and basic rocks associated with the metasediments in the Basement of the Eastern Desert, which are also present under comparable conditions in Saudi Arabia and the Sudan.

(c) Non-ferrous sulphide deposits, auriferous veins, etc. are connected with the hydrothermal activity of the late tectonic granites in the Basement of the UAR which belong to the late Pre-Cambrian - early Palaeozoic activity so widespread in the African shield. Absolute ages of the granites and related mineralisations in Africa and Asia are ranging from 640 to 480 million years, with stages of magmatic activity embracing those of Katanga and Madagascar of the Indian Ocean tectonic cycle.

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(1) Holmes, A. and Cahen, L., African geochronology, Colonial Geology and Mineral Resources, 5, 5-38 (1955).

(d) Sedimentation produced large scale deposits of phosphates, and iron and manganese ores in the UAR especially in formations ranging in age from the Carboniferous to the Eocene (FIGURE I). The most important of these are the phosphates which form a part of a large province extending from northern Africa to western Asia.

(e) The telethermal Miocene lead-zinc deposits on the Red Sea coast in the UAR are believed to be related to the outer manifestations of the magmatism of the Alpine tectonic cycle. Typical and deeper representatives of this cycle are encountered in North Africa and southern Europe.

3. Mineralogical guides: These are represented by the notable alteration zones round the epigenetic mineral deposits, oxidised ore minerals exposed at the surface, primary minerals, and characteristic gangue minerals. In the UAR quartz has been used as a guide mineral for the true hydrothermal veins such as those carrying gold, cassiterite and wolframite as quartz gangue is almost always associated with these veins. The characteristic green and blue colours of the oxidised copper minerals notably malachite and atacamite have been utilised in the search for deposits of copper and associated minerals, most copper discoveries have been due to the application of this guide. Furthermore, the recognition of the red gossan produced by the oxidation of pyrite and marcasite associated with the telethermal lead-zinc deposits led to the discovery of Um Gheig mine by a prospector.

4. Structural guides: Shear zones, faults and fractures are some of the most clear structures controlling the localisation of epigenetic mineral deposits. It has been established that the zinc-copper-lead sulphide deposits at Samiuki, Eastern Desert are essentially localised in shear zones trending N.W. - S.E. to E. - W. in Pre-Cambrian metavolcanics (2), and this has been used as a guide for searching for similar deposits thus leading to the discovery of Abu Gurdi and other occurrences. An important guide in sedimentary formations is deposition on unconformities. A good example is illustrated by the iron ore deposits of Baharia Oasis, which were first discovered at Gebel Ghorabi and later traced in other localities (3), mainly by making use of the fact that the ores are found on the unconformity between the Cretaceous and the Eocene.

5. Lithological guides: Some mineral deposits are connected with certain host rocks, this is particularly true for deposits where magmatic segregation plays a dominant role, although lithological guides apply in certain cases to epigenetic and sedimentary deposits. In the Pre-Cambrian of the Eastern Desert chromite is found only in ultrabasic rocks, and ilmenite and ilmenite-magnetite deposits are restricted in their occurrence to altered gabbros. Search for the previously mentioned ores is only restricted to their well-defined host rocks. Furthermore, telethermal lead-zinc deposits in Miocene sediments, although they occur in several types of rocks, however, they only reach economic grade in limegrits which are constituted of a mixture of lime, sand and clay. Several examples are known in which sedimentary deposits are controlled by the lithology of the enclosing formations, among these are the metamorphosed iron ore bands occurring in association with calcareous mudstones at several localities in the basement rocks in the central Eastern Desert. (4)

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(2) El Shazly, E.M. and Afia, M.S., Geology of Samiuki deposit, Eastern Desert, Egyptian Journal of Geology, 2, 25-42 (1958).

(3) Akaad, S.E. and Zaatout, M.A., The iron ore deposits of Baharia Oasis, First Iron and Steel Conference, Cairo, 1-35 (1961).

(4) Shukri, N.M., El Shazly, E.M. and Sabet, A.H., The iron ore deposit of Umm Ghamis El Zarqa, Eastern Desert, Egyptian Journal Geology, 3, 125-146 (1959).

6. Stratigraphic guides: These are particularly remarkable for following large scale sedimentary deposits occurring in certain well-defined stratigraphic horizons. The best example in the UAR is illustrated by the phosphates which occur in the Maestrichtian-Campanian, and their presence was anticipated and discovered in widely separated areas by the application of their stratigraphic guide. This also applies, but to a lesser extent, to the Senonian oolitic iron ores in the Nubian Series to the east of Aswan, and the manganese-iron deposits localised in the Carboniferous sediments in Sinai which have been recently recorded in the Carboniferous rocks of Wadi Araba on the western side of the Gulf of Suez (A.M. Abdulla, personal communication).

7. Advantages and limitations of geological exploration: As a general rule it has been found out by experience that geological guides and study of the geology of explored areas are essential for scientific prospecting, this is especially true for arid regions where rock exposures are common. In some cases geological methods give enough data, however, in others they have to be supplemented by geophysical, geochemical, exploratory mining or drilling. Disadvantages of the sole application of geological methods include cases where considerable areas are sometimes covered with windblown sand and alluvial deposits, or the outcropping part of a mineral deposit may be too small to give a reasonable idea about its potentialities, apart from the fact that it is easier sometimes to detect mineral deposits by a distinct physical property such as radioactivity rather than by applying geological guides.

Aerial Photographs and their Application for Exploration

8. Aerial photographs and geological mapping: Most of the territory of the UAR is at present covered by vertical aerial photographs on a scale ranging from 1 : 20,000 to 1 : 60,000 with the exception of some areas in the southern Western Desert. The advantages of using these aerial photographs in geological mapping and mineral exploration have been appreciated in a short time, and they have been utilised for this purpose except in some cases where detailed mapping and investigations are needed. It is generally established that geological maps are of fundamental importance to mineral exploration, and the use of aerial photographs in preparing geological and topographical maps in a much shorter time and with about one third of the expenses of the classical methods is a considerable contribution to the progress of mineral exploration.

9. Aerial photographs and geological exploration: In some cases it has been possible to observe directly a mineral deposit or its debris and to follow its extension on the photographs. This is exemplified by the iron ore deposits of Baharia Oasis in the Western Desert where the debris of the ore are considerably darker in tone than the associated sediments. However, in most cases, mineral exploration is carried out indirectly through the recognition of the characteristic geological guides on the aerial photographs. Of these, regional guides may be broadly applied by examining photographs of the suitable region in the office and choosing the areas where geological conditions are most favourable for mineral deposition, and accordingly to direct the activities of the exploration parties to these areas.

10. Shear zones as notable structural guides and talcose alteration products have been observed in the aerial photographs of Samiuki mine (FIGURE II), the extension of this polymetallic mineralisation and the location of other shear zones in the Pre-Cambrian metavolcanics have been partly carried out by the examination of the photographs of the surrounding areas.

11. Lithologic guides are expressed on the aerial photographs when the favourable host rock may be differentiated from the associated formations. The host rocks

for the ilmenite and ilmenite-magnetite deposits of Abu Ghalqa and Abu Dahr respectively, namely the Pre-Cambrian altered gabbros are readily recognised from the surrounding metavolcanics and granites, and the possibilities of the lateral distribution of the ore bodies have been determined accordingly.

12. Stratigraphic horizons connected with certain stratified mineral deposits are sometimes clearly distinguished from the associated horizons, and this has been utilised to follow the extension of the deposits in question by examining the photographs of the favourable areas and localising their particular stratigraphic guide. In Maghara area, northern Sinai, coal-bearing bands are intercalated with a flinty limestone series at the base of the Bathonian, the latter series is characterised by its dark tone in comparison with the associated Bathonian limestone-shale intercalations and the underlying light grey Bajocian limestone (M.B. Morcos, personal communication).

13. Physiography has been found to be useful as a guide in the search for the metamorphosed banded iron ores in the Eastern Desert, although it does not itself indicate the presence of these bands. Conspicuous ridges are visible on the aerial photograph of Um Nar deposit (FIGURE III), which are caused by the differential weathering of the hard iron ore bands and the softer metasediments.

14. Aerial photographs and geophysical and geochemical exploration: Geophysical flight lines, ground geophysical traverses and profiles, geochemical traverses and profiles, and delineation of areas for biogeochemical prospecting are planned and carried out directly on aerial photographs and mosaics especially in areas where appropriate maps are not available.

15. Advantages and limitations of aerial photographs in exploration: As a general rule it has been found out by experience that aerial photographs are helpful in mineral exploration especially in general planning, preparation of necessary geological maps and recognition of the obvious mineral guides. Occasionally, but not very often the photographs gave a direct clue to a mineral deposit. In detailed work additional close geological examination and mapping by classical methods are of considerable significance. In areas where outcrops are common aerial photographs are particularly useful and these are of wide distribution in the UAR, however, some parts of the Western Desert are covered with great sand dunes and the valleys are normally covered with alluvium in which cases the application of aerial photographs in exploration becomes very limited.

Geophysical Methods and their Use in Mineral Exploration

16. These methods essentially make use of notable differences in some physical properties between mineral deposits and associated rocks, or between different formations where structural information is needed. Among the geophysical methods recently applied for mineral exploration in the UAR are included the magnetic, radiometric and electrical.

17. Magnetic methods: Aeromagnetic surveys have been carried out in these areas, namely northern Egypt, southern Western Desert and central Eastern Desert. The last area has been particularly chosen for mineral exploration with special emphasis on the metamorphosed iron ores which are already outcropping at thirteen localities. Prospection is carried out by AM 13 magnetometer mounted on AN 2 planes which fly at an altitude of 200 mrs. from the ground at a speed of 180 Km/hour. The spacing between successive flight lines is 1 Km., and the direction of the lines is ENE - WSW which is perpendicular to the main structures of the Basement and the sedimentary cover. Graphs and isoline maps of magnetic field

are finally prepared on a scale of 1 : 100,000 (5). The results of the survey have been useful in locating the extension of some metamorphosed iron ores, elucidating the major structures in the area, and in mapping rocks with notable magnetism such as basalts hidden under sediments.

18. Moreover, ground magnetic surveys have been applied in several mineralised areas and positive results obtained for the metamorphosed iron ores and ilmenite-magnetite deposits. Magnetite-hematite iron ore bands have been located under an overburden of alluvium in several localities in the Eastern Desert including Dabbah, Karim, Um Ghamis and Gebel El Hadid by means of geomagnetic measurements, with Askania field balances. At Abu Dahr several ilmenite-magnetite bodies have been discovered in gabbro, and their extension under the valley alluvium and in depth verified by a magnetic survey using M 2 magnetometer (6). In common with previous Canadian experience the ilmenite ore of Abu Ghalqa which contain hematite exsolutions, gave negative anomalies in comparison to the positive anomalies exhibited by the magnetite-bearing gabbro, which constitutes the host rock.

19. In exploration for copper deposits in the Basement magnetic methods gave positive results when the mineralised shear zones and adjacent country rocks contain magnetite which is usually more abundant in the shear zones. However, in many cases both are free from magnetite and these methods are not applicable. Furthermore, the sedimentary and replacement iron and manganese ores in the sedimentary formations did not respond to magnetic exploration methods as the deposits and associated rocks do not contain magnetic minerals.

20. Radiometric methods: Regional surveys and reconnaissance have been carried out by aerial and carborne radiometric methods, and in such cases radiometric traverses, profiles and maps are plotted on a scale of 1 : 100,000. In aerial radiometric surveys airborne gamma radiation detectors PBC 1 mounted on Beachcraft or AN 2 planes have been used. Flight is normally kept at about 50 mrs. above the ground, spacing between successive lines being 1 Km. and their direction is kept perpendicular to the main structures of the investigated areas.

21. Carborne scintillation surveys have been successful in regional and semi-detailed exploration for radioactive deposits, the resulting anomalies in this case could be examined and verified on the spot. The efficiency of carborne methods depends to a great extent on the topography of the examined area and the passability of its valleys. The average density of profiles in an area of moderate topography in the Eastern Desert (7) is calculated to be 0.735 Km/Km.^{2} which is rather small, and in addition this density is not equally distributed within the same area. However, it has been possible to discover uraniferous deposits by regional carborne prospecting and to follow these occurrences by analogy with comparable geological formations and semidetailed carborne and foot prospecting, and finally by detailed radiometric foot prospecting and geological mapping.

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(5) Fahim, M., Project of work for aerogeophysical exploration in the Eastern Desert, 1961-1962, Unpublished report, Geological Survey and Mineral Research Department (1961).

(6) Garkov, Report on the geophysical work in Abu Dahr area, Unpublished report, Geological Survey and Mineral Research Department (1960).

(7) Nedimovic, R., Hussein, H.A. and Obrenovic, M., Report on the prospection for uranium by the Yugoslav-United Arab Party during the period December 1961 - March 1962, Unpublished report, Atomic Energy Establishment, Cairo (1962).

Geochemical Methods in Mineral Exploration

22. Geochemical methods imply the analysis of soils, waters and vegetation, and the application of the resulting chemical anomalies to trace mineral deposits. These methods have been applied in the UAR during the last three years especially in known areas with lead, zinc, copper and nickel mineralisations. Normally closely spaced grid system is used and point samples are taken from the friable superficial deposits to a depth of about 20 cms., quartered and sieved to take the fine fraction and subjected to semi-quantitative spectrographic analysis. Finally the chemical values are put on maps and plotted as lines of equal concentration of the elements sought for. In the area of Zug El Bohar high values of lead and zinc have been encountered for a distance of 50-100 mrs. from the known lead mines (8). Geochemical anomalies have been located in the vicinity but not yet checked to prove or disprove them. So far, some difficulties in applying geochemical exploration are encountered due to the fact that fine eluvium is not so common, and water points and plants are scarce under desert conditions.

Drilling and Exploratory Mining

23. These methods are necessary to obtain precise information on the extension of mineral deposits laterally and in depth, and the tonnage and grade of the ore under exploration. For deposits exposed at or near the surface trenches and pits are made and are found to be in several cases more useful than drilling. In addition, it has been found out that mining is more convenient than drilling where topographical conditions are not convenient for the latter, recovery by drilling is low, and when large technological samples are required. Otherwise drilling is normally used especially in cases where attaining considerable depths is needed and exploration mining will become expensive. Percussion drilling has been successful in comparison to rotary drilling in the friable Miocene lead-zinc deposits and in Baharia iron ores which may be earthy or cavernous. However, rotary drilling is recommended in most cases as it is versatile and quick especially in hard formations, and where greater depth or inclined holes are required.

Coordination in Mineral Exploration

24. By the advance of exploration and the diversity of the methods applied two factors become important, namely, the choice of the most suitable methods for each particular mineral deposit and coordination of the activities related to this problem to achieve the best and most economic results. In common with other countries, our experience points out that regional geological maps compiled with the help of aerial photographs combined with aeromagnetic surveys provide the basis for scientific exploration. In arid regions due to the common occurrence of good exposures geological guides and surface geological investigations should be fully exploited. The knowledge of the types of deposits sought for helps by comparison to choose the most suitable geophysical and geochemical methods especially in the use of magnetic and radiometric methods in the search for magnetic and radioactive minerals respectively. In other cases complex surveys may have to be conducted and the best methods found out empirically. Complex geophysical and geochemical surveys have been carried out at typical mineralised areas in the UAR to test the most suitable and cheapest exploration methods for further application in comparable areas. Coordination of the activities of the various organisations engaged in mineral exploration and related problems including those of petroleum and ground water are significant for the compilation of data,

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(8) El Hakim, H. and Kamel, F., Report on geophysical work for lead-zinc prospection in Zug El Bohar area, 1960 Unpublished report, Geological Survey and Mineral Research Departmen 1961).

exchange of experience, division of labour, etc. This is carried out on the scientific level through the Science Council and on the industrial level through the Organisation for the Execution of the Five Years Industrial Plan, or by direct contact between the organisations concerned.

Suggestions for the Development of Mineral Exploration

25. It is most important for developing countries to achieve a sound mineral economy which could only be realised through a vigorous and organised programme for mineral exploration whose immediate fruits may not be startling but its solid results will unfold themselves within perceptible time. It is believed that the following suggestions will be of some help to developing countries in this respect:

(a) To establish national geological services if they are not in existence and to strengthen the existing ones. These services should be at least responsible for the fundamental basis of mineral exploration, their share in other activities will depend on the circumstances of each country.

(b) To coordinate the activities of the organisations dealing with mineral exploration and related matters through planning bodies on the scientific and industrial levels.

(c) To develop efficient means of publication and exchange of ideas especially between countries lying in the same comparable geological, geographical and physiographic regions. This will help to assess their mineral potentialities and to choose the most suitable guides and exploration methods by correlation.

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FIGURE III. Conspicuous ridges at Um Nar iron ore deposit, Eastern Desert.

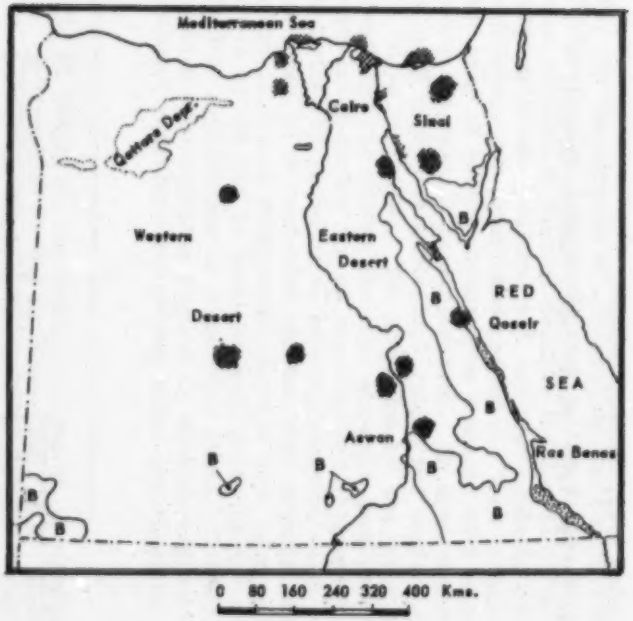

FIGURE 1
Map of the U.A.R. showing general distribution of areas of mineral deposition.

Sedimentary cover

Basement, Areas of Pre-Cambrian to Palaeozoic mineral deposition

Areas of Quaternary mineral deposition

Areas of Miocene mineral deposition

Areas of sedimentary Carboniferous to Eocene and probably Oligocene deposits

FIGURE II. Shearing at Samiuki mine area, Eastern Desert.

FIGURE III.
Conspicuous ridges at Um Nar iron ore deposit Eastern Desert.

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